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XXXIII. *A Letter from Joseph Willard to the Rev. Dr. Maskelyne, Astronomer Royal, concerning the Longitude of Cambridge in New England.*

Read July 5, 1781.

REV. SIR,

THE difference of meridians between Greenwich and Cambridge has been generally reckoned 4 h. 44'. This was what the late Dr. WINTHROP made use of; but I do not find that he determined it by actual observations, made by him at Cambridge, compared with corresponding ones, made at the Royal Observatory at Greenwich. It appears, that in 1769, at the time of the transit of Venus, the doctor was not entirely certain of the longitude of Cambridge. He mentioned 4 h. 44' as near the truth; but for better fixing it, he gave several of his observations of the eclipses of Jupiter's satellites to be compared with those made at Greenwich; but there were too few corresponding ones to determine the point with precision; and as modern astronomers do not make absolute dependence upon the difference of meridians deduced from the eclipses of Jupiter's satellites, unless there has been a series of observations, both of immersions and emersions, I have wished to find some observations of solar eclipses and occultations of fixed stars by the moon, made at Cambridge, of which corresponding ones were made at Greenwich. I have met with no observations of occultations made by Dr. WINTHROP; but a solar eclipse

eclipse was observed by him and several other gentlemen, at his house, August 5, 1766, at which I was present and assisting, being then a resident graduate at Harvard College: this eclipse, Sir, I find that you observed at Greenwich. By your observations in the printed volume, a copy of which the Royal Society was so generous as to send to Harvard College, which was received the last spring, and for which the College is very grateful, I find the beginning of the eclipse was seen by you at 5 h. 29' 56" P.M. and the end at 7 h. 11' 27" P.M. apparent time. At Dr. WINTHROP's house at Cambridge, lat. $42^{\circ} 25'$ N. the beginning of this eclipse was observed at 11 h. 39' 23" A.M. and the end at 2 h. 45' 9" P.M. apparent time. Allowing for the spheroidal figure of the earth, and going through the parallaxic calculations and deductions, I find the difference of meridians between Greenwich and Cambridge, by the observations of this eclipse, to be 4 h. 44' 22".

In the transit of Venus, in 1769, the internal contact was observed by Dr. WINTHROP at 2 h. 47' 30" apparent time, and by Mr. HITCHINS, at the Royal Observatory, at 7 h. 28' 57" apparent time. Allowing the sun's parallax on the day of the transit to be $8''.38$, I find by calculation from these observations, that the difference of meridians between Greenwich and Cambridge is 4 h. 44' 12". The reason of my taking Mr. HITCHINS's observation is, your saying, that the telescope which he used was much superior to all the others which were made use of at that day at the Observatory; and to its greater excellence and distinctness you attribute the difference of 26" by which Mr. HITCHINS saw the internal contact before you. There seems to be the greater propriety, when comparing the American observations of that phenomenon with those made at Greenwich, to take that where the observer was peculiarly

aided by the distinctness of his telescope, because the sun was very near the horizon with you, while with us the altitude was great, and the atmosphere exceeding clear. Taking the mean between the deduction made from the observations of the internal contact of Venus, and of the beginning and ending of the above solar eclipse, the difference of meridians between Greenwich and Cambridge is 4 h. 44' 17".

I find, Sir, in a letter from you to Dr. SMITH of Philadelphia, Dec. 26, 1769, that by the observations of the eclipses of Jupiter's satellites made at Norriton you determined the difference of meridians between Greenwich and Norriton to be 5 h. 1' 0' 35". If we subtract 52", the difference of meridians between Philadelphia and Norriton, gotten, agreeably to your request, by terrestrial measurement, we find the difference of meridians between Greenwich and Philadelphia to be 5 h. 0' 43", which is the same that it appears to be by the immersions and emersions of Jupiter's first satellite observed at Philadelphia, corrected in the same manner you corrected the observations for Norriton, which is 8" more than Dr. EWING's determination. By observations of the transit of Mercury in 1769, made at Cambridge and Philadelphia, the difference of meridians between those two places appears by the external contact to be 16' 02", by the internal 16' 28"; the mean 16' 30" subtracted from 5 h. 0' 43" leaves 4 h. 44' 13" for the difference of meridians between Greenwich and Cambridge deduced in this way, which, though not direct, may yet be considered as an evidence of some weight to prove, that the difference is more than 4 h. 44', and that 4 h. 44' 17" may be very near the truth. This is the difference that I at present take, when I make use of tables fitted to the meridian of Greenwich; but I should be still glad of more corresponding

corresponding observations to ascertain this point. June 24, 1778, there was a solar eclipse, visible both at Greenwich and Cambridge. The beginning of this eclipse was observed at Cambridge by the late Dr. WINTHROP at 9 h. 6' 20" A.M. and the end at 11 h. 37' 22" A.M. apparent time. If the atmosphere favoured your observing it at Greenwich, I should be extremely obliged to you, if you would communicate to me your observations. I shall also be happy to know the time of the beginning of the solar eclipse of the 23d of next April at Greenwich.

I now, Sir, beg leave to communicate to you some observations of the solar eclipse of the 27th of last October. At Beverly, lat. $42^{\circ} 36'$ N. I carefully ascertained the going of my clock, by equal altitudes of the sun's upper and lower limb, for several days preceding the eclipse, and on the day when it happened, constantly applying the equation for the change of declination. October 25th, when the sun's center passed the meridian, it was by the clock 11 h. 59' 11"; on the 26th, 11 h. 58' 15"; and on the 27th, 11 h. 57' 18".

Two gentlemen observed with me; the rev. Mr. CUTLER of Ipswich, and the rev. Mr. PRINCE of Salem. Mr. CUTLER and I were each furnished with a reflecting telescope made by JAMES MANN of London, one magnifying 34, and the other 45 times. Mr. PRINCE had an achromatic refractor magnifying 43 times. The times of observation are as follow :

		By the clock.	Reduced to app. time.
		h. ' "	h. ' " A.M.
Beginning of eclipse ob- served by	Mr. CUTLER,	10 59 2	11 1 42
	Mr. PRINCE,	10 59 6	11 1 46
	Myself,	10 59 8	11 1 48
End of eclipse observed by	Mr. CUTLER,	1 38 37	1 41 23 P.M.
	Mr. PRINCE,	1 38 43	1 41 29
	Myself,	1 38 40	1 41 26

I had no micrometer to measure the lucid part of the sun in its least state, and thereby determine the error of MAYER's tables in latitude at the middle of this eclipse. But according to the observations of Professor WILLIAMS, Dr. WINTHROP's successor, the error was not great. He and several assistants observed this eclipse at Long Island in Penobscot Bay. The latitude of the place of observation he found to be $44^{\circ} 17' 7''$ N. He observed the beginning of the eclipse at 11 h. 11' 8'' A.M. and the end at 1 h. 50' 25'' P.M. apparent time. He was furnished with an excellent DOLLOND's micrometer, with which he measured the sun's diameter on the morning of the eclipse, and the lucid parts many times during its continuance. By his observations, compared with those made at Beverly, I find the difference of meridians between Beverly and Long Island to $8' 4''$ in time. The time of the greatest obscuration was at 12 h. 30' 22'', when the lucid part of the sun was $8''$ on the lower limb. The sun's semi-diameter according to observation was $16' 8'',7$; the moon's horizontal semi-diameter, according to the tables, $16' 23'',8$; the augmentation of her semi-diameter, agreeably to her altitude, $9'',5$; the sum of the visible semi-diameters of the sun and moon therefore $32' 42''$. The lucid part of the sun $8''$ being subtracted from $32' 17'',4$, the sun's diameter, leaves $32' 9'',4$ for the eclipsed part of the sun, which subtracted from $32' 42''$ leaves $32'',6$ for the least distance of the centers of the sun and moon. The visible angle of the moon with the sun was, I find, $15^{\circ} 54' 54''$, and her motion from the sun in her visible orbit $24'',5$ in one minute; the visible ecliptic conjunction therefore was at 12 h. 29' 57'', and the distance of the centers of the sun and moon $34''$. The moon's parallax in latitude from the sun was then $49' 15'',8$ S. which added to $34''$ gives $49' 49'',8$ N. equal to the moon's lati-

tude by observation. By MAYER's tables her latitude was then $49^{\circ} 39''$, 4, by which it appears, that the error of these tables in latitude, at the middle of the eclipse, by the Penobscot observation, was $-10''$ 4. The error in longitude, taking the mean between that of the beginning and end, I find to be $-9''$. The determination of these errors is upon the supposition that Beverly is 4 h. 42' 59'' W. of Greenwich, which, I believe, very near the truth. Beverly appears by observation to be 1' 18'' in time E. of Cambridge, which subtracted from 4 h. 44' 17'' leaves 4 h. 42' 59''.

I hope, Sir, no umbrage will be taken at my writing to you, on account of the political light in which America is now viewed by Great Britain. I think political disputes should not prevent communications in matters of mere science; nor can I see how any one can be injured by such an intercourse.

I am, &c.

Beverly in Massachusetts,
February 16, 1781.

